White Paper and Strategic Straw plan for BioXAS Facility at NSLS-II

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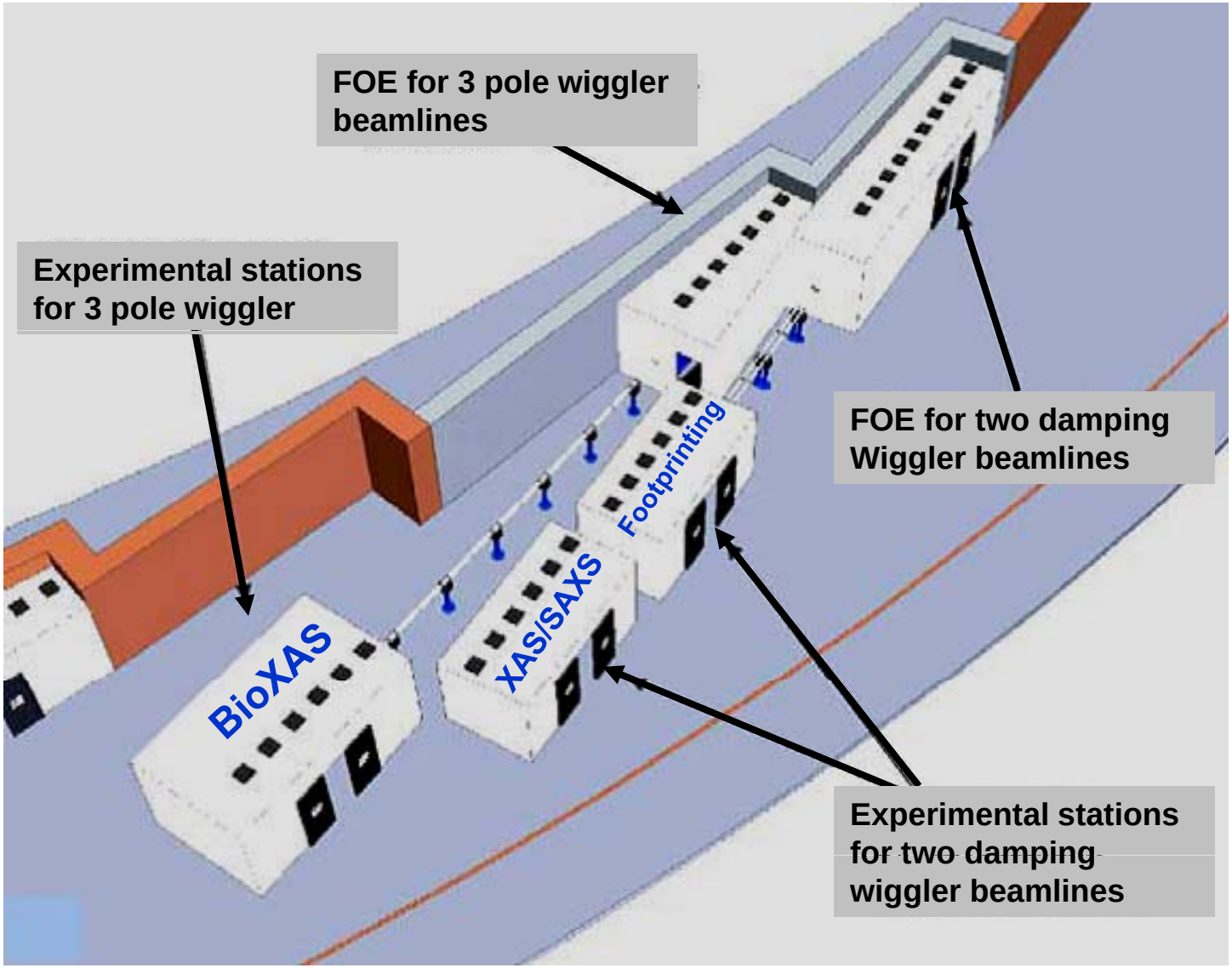
BioXAS related requirements at NSLS-II

- ❑ EXAFS measurements on life sciences samples – existing program
- ❑ High-throughput metalloproteins screening – existing program
- ❑ XAS on screened metalloproteins samples –proposed expansion of the existing program
- ❑ X-ray microprobe studies and imaging microscopy
- ❑ Time resolved BioXAS

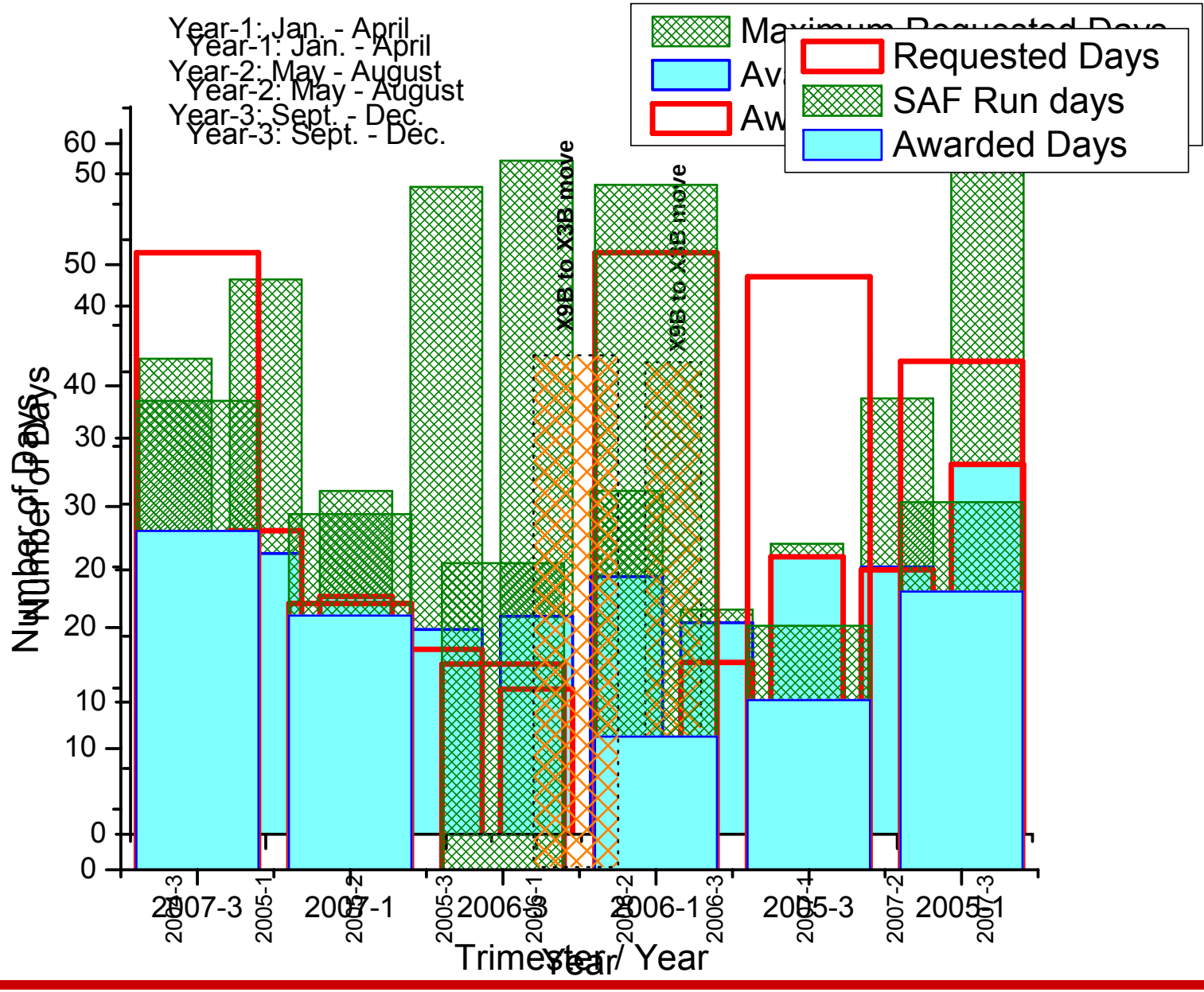
X3B BioXAS program....future NSLS-II candidate

- ❑ High User Demand (increased to 50% in summer 07, up to 75% in next 5 years)
- ❑ High in-house research usage (metalloproteomics programs and other multidisciplinary projects)
- ❑ High Productivity (~ 45 publication in 2006-2007)
- ❑ High quality service to the users – both technical and scientific
- ❑ Scientific breakthroughs
- ❑ Protein Structure Initiatives (PSI) collaboration – metalloproteomics
- ❑ "Mail-in" and "Drive-by" program
- ❑ Consistency and compatibility between existing X3B at NSLS-I and future BioXAS at NSLS-II
- ❑ State-of-the-art instruments: proposed new monochromator and a 31 element Ge detector (to be moved from X3B)

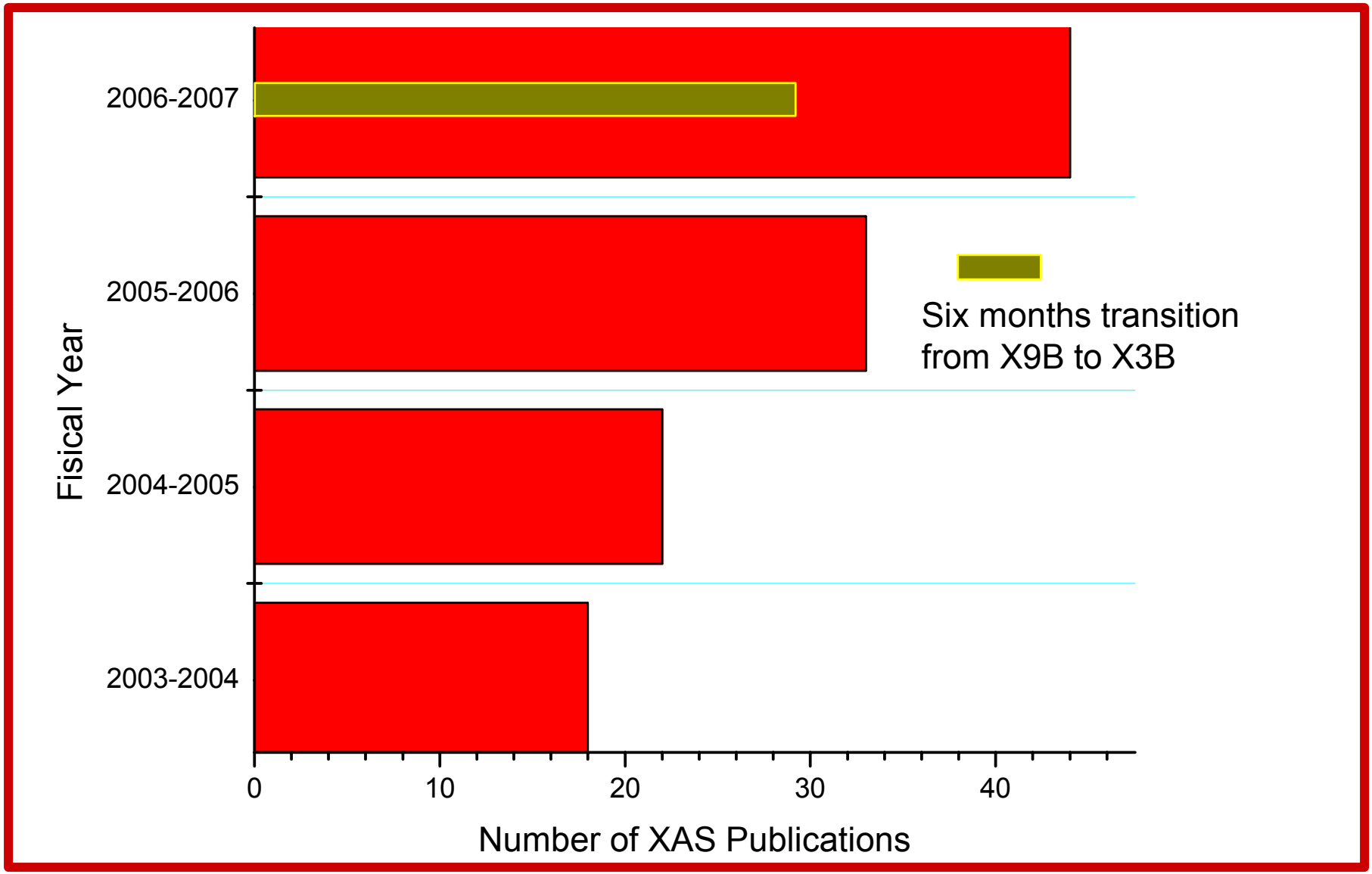
Proposed BioXAS beamlines at NSLS-2



X9B/X3B demand and usage



X3B/X9B publications



Significant Upgrades (last five years)

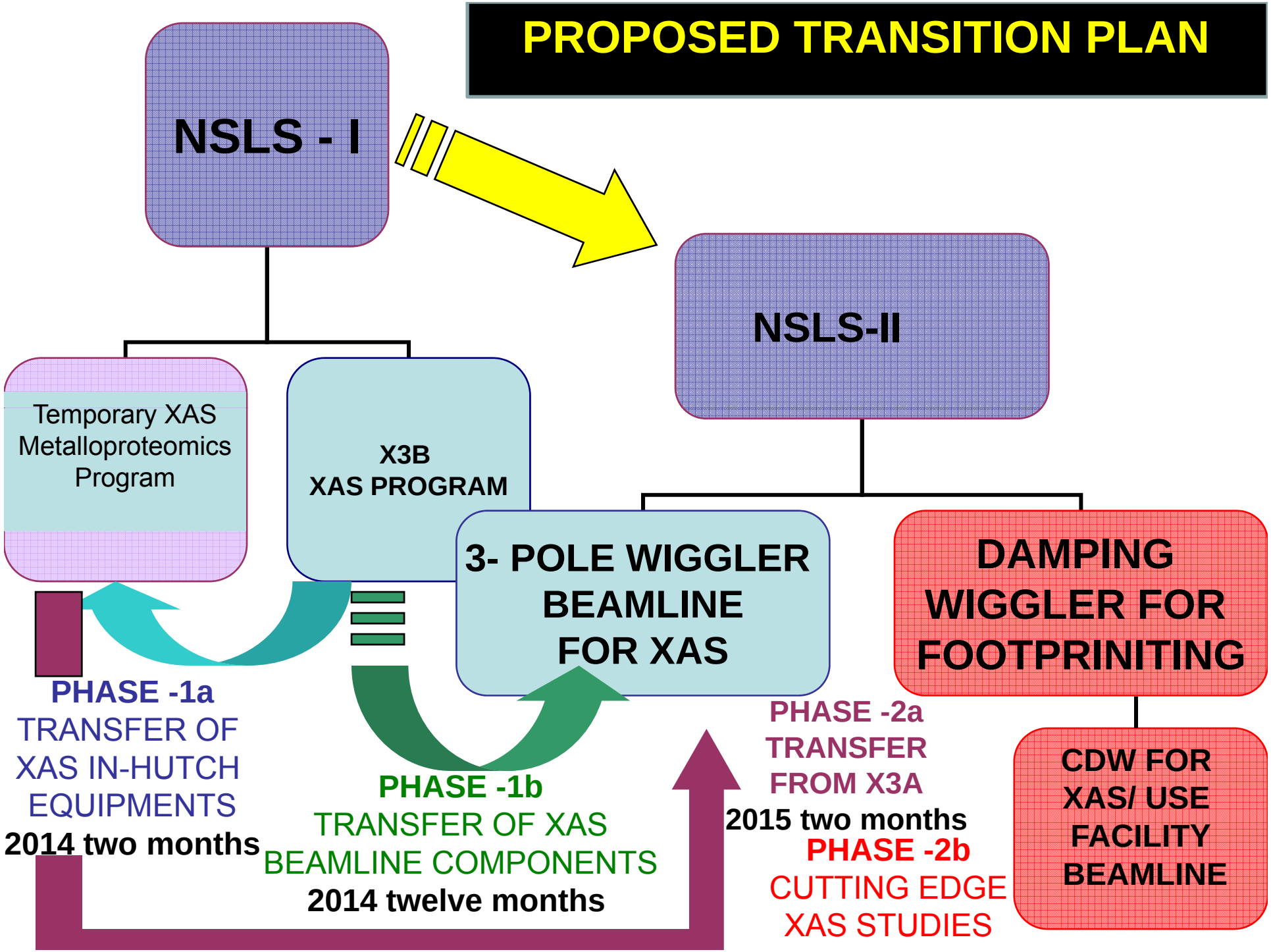
- New sagittal focusing crystals (achieved ~ 2.5 fold increase in flux)
- Dynamic focusing using motorized bender (achieved constant spot size)
- 13 element detector
- Sample-reference laser alignment
- New experimental precision bench
- A state-of-the-art set-up for metalloproteomics program (screen 176 proteins in 7-8 hours)
- “Mail-in” and “Drive-by” program

Proposed future upgrades -next 5 years

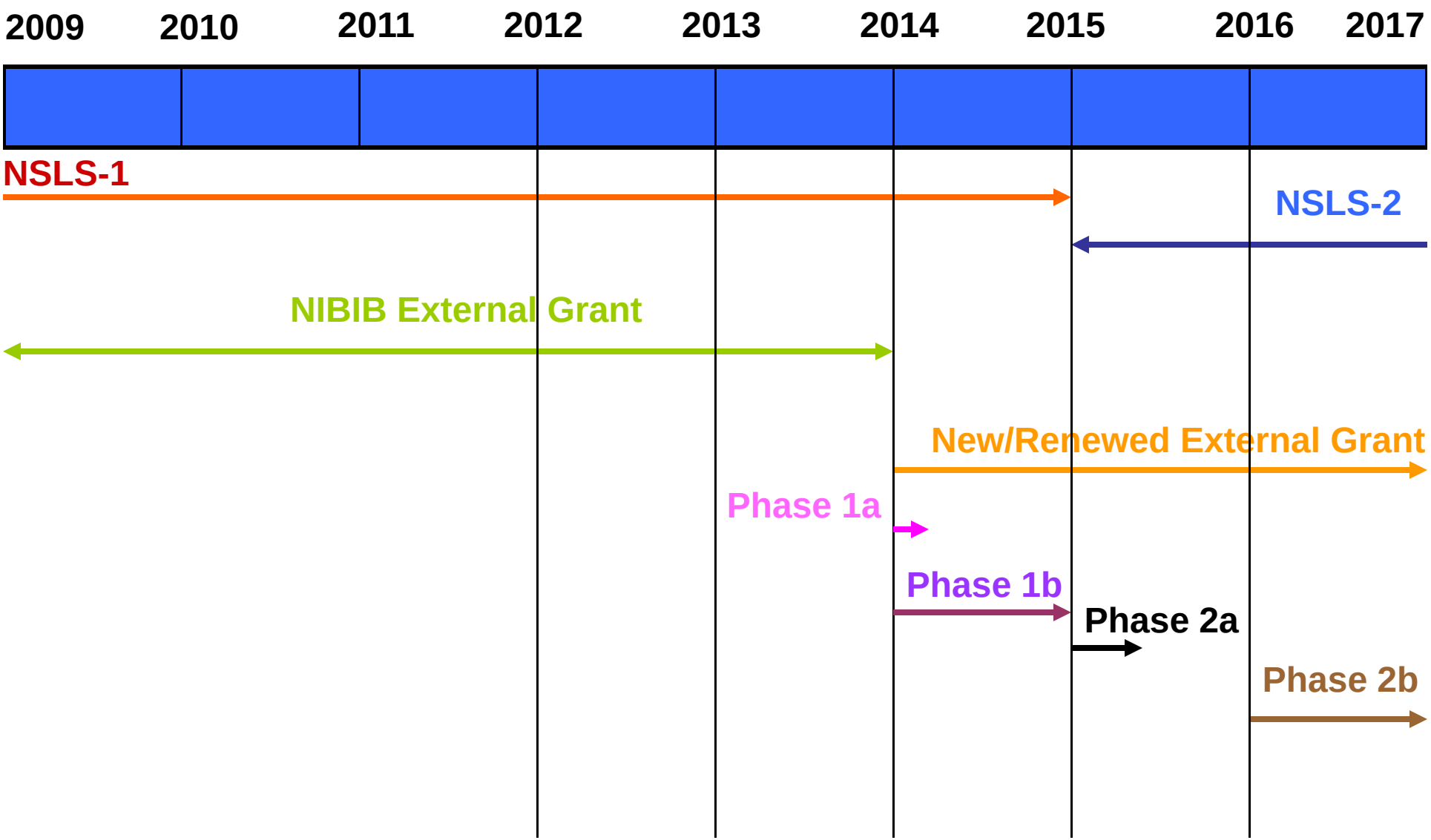
- **New Monochromator**
  - Present mono (water cooled) is suitable for a 3-pole wiggler
  - New proposed mono will have capability of working at canted DW with both cryo-cooled crystals
- **New Detection system (31 element detector with digital electronics)**
  - The present detection system can be dedicated to metalloprotein screening (high throughput metalloproteomics program)
  - Advantages of new system includes:
    - Low detector saturation (ability to use high flux beam)
    - Ability to measure low concentration samples (increased total active area)
    - Increased data quality (faster data acquisition)
    - High throughput studies (more region of interest selection)
- **Upgrade the metalloproteomics sample holder, stage and sample loading system**

Anticipate additional upgrades by 2015 for smooth transition to NSLS-II

- New detector and control system
- Possibility for broader energy coverage
- Rapid (sub-second) tunability across an edge
- Planned upgrade of monochromator
- Cryo sample changer for multiple samples
- Semi-automatic sample centering system
- On line sample annealing assembly


PROPOSED TRANSITION PLAN
NSLS - I
NSLS-II
Temporary XAS Metalloproteomics Program
X3B XAS PROGRAM
3- POLE WIGGLER BEAMLINE FOR XAS
DAMPING WIGGLER FOR FOOTPRINITING
CDW FOR XAS/ USE FACILITY BEAMLINE
PHASE -1a
TRANSFER OF XAS IN-HUTCH EQUIPMENTS
2014 two months
PHASE -1b
TRANSFER OF XAS BEAMLINE COMPONENTS
2014 twelve months
PHASE -2a
TRANSFER FROM X3A
2015 two months
PHASE -2b
CUTTING EDGE XAS STUDIES

Funding and time Line



BioXAS at NSLS-II

- The users time will increase to 80% with 20% for developmental activity
- Expansion of in-house metalloproteomics program
- Full support from the CSB team to run the life science XAS program, help users to submit proposals and beamtime management
- Expansion of mail-in and drive-by program

END

Slide 1: Summary of long term scientific program at X9B/X3B, Impact on science, Publications, Significant upgrades, Proposed upgrades in next five years,

Phase 1 Proposed transfer of X3B hutch components to X3A and X3B beamline to a 3-pole wiggler line

Phase 2a Proposed transfer of X3A beamline to a 3-pole wiggler line

Phase 2b Cooperation with the DW project specialized beamlines for the cutting edge life science related XAS experiments such as flow cell, time resolved XAS experiments, microprobe XAS experiments

Phase 3 Building an additional canted wiggler XAS beamline in conjunction to the proposed DW footprinting beamline

Slide 2: Transition plan:

Option 1: Move X3B to X3A while transition

Slide 3: Staff support in running the life science program, helping users to submit proposals and beamtime management, etc.

Slide 4: Global impact on users →80% time for user community and 20% for developmental activity

Growth of in-house projects such as metalloproteomics

Transfer will require smoother and quicker transition

Metalloproteomics in Structure Genomics

- High-throughput characterization of metalloproteins using X-ray absorption spectroscopy

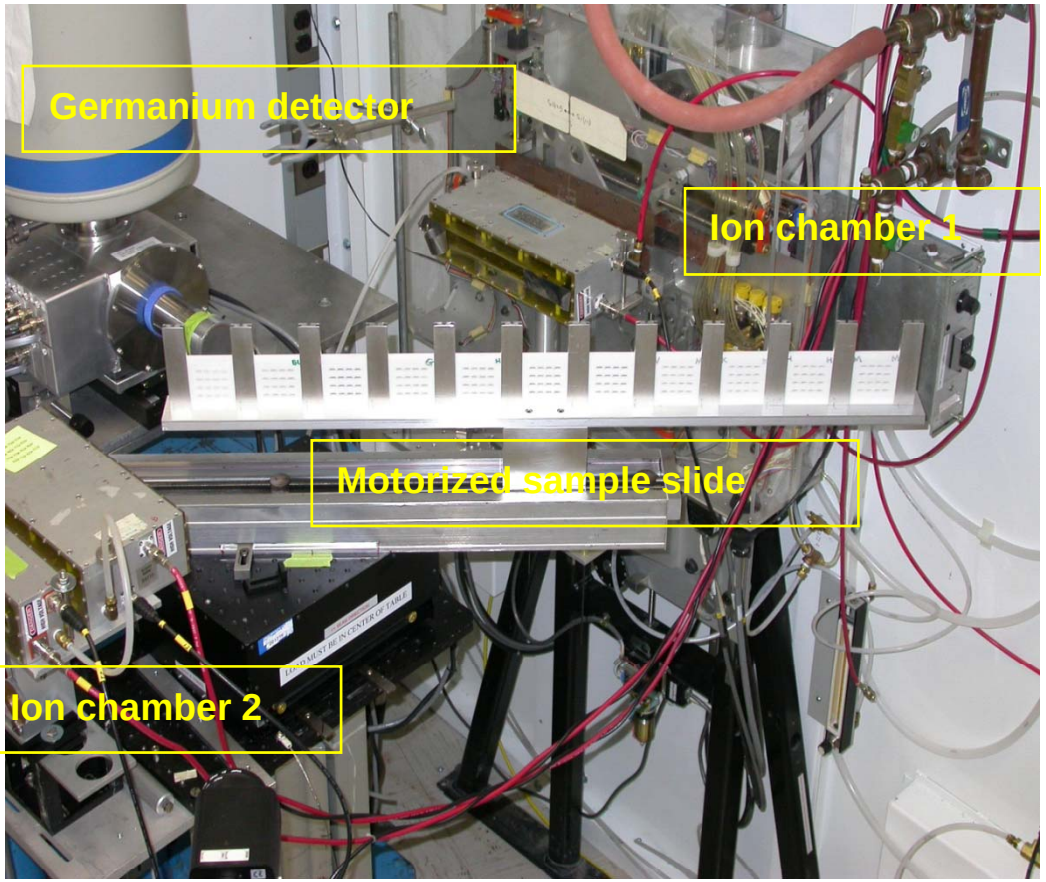
- Developed in structure genomics to assist crystallographic phasing, functional and structural annotation of metalloproteins

- 2164 (654 in PSI – 1 and 1510 in PSI – 2 NYSGXRC proteins analyzed and 10% showed presence of a transition metal (Zn, Mn, Ni, Co and Cu)

- 95% accurate based on 143 solved crystal structures

- Long term goal: to establish a metalloprotein database
~ 1000 families are covered so far

Experimental Setup at Beamline X3B



Lab Space Specification and Location

- ❑ Clean Room
- ❑ Fume Hood
- ❑ Oven and Furnace
- ❑ 80 K deep freeze refrigerator
- ❑ Centrifuge and related instruments
- ❑ Sample storage and cold room
- ❑ Sample preparation work bench space
- ❑ Storage space for excess equipments
- ❑ Electronics and beamline instrumentation construction lab

Office Space Specification and Location:

- ❑ Near to the beamline if possible
- ❑ 1 or 2 staffs per office room

Instrumentation Lab Space and Location :

- ❑ Near to the beamline
- ❑ Large enough to provide a work space of at least 3 personnel

Key attractions of XAS for Biological Research:

(1) XAS provides information on electronic and atomic structure for both crystalline and non-crystalline systems;

(2) XAS is a comprehensive atomic level structural tool sensitive to within ~ 4-5 Å of metal sites;

(3) XAS allows an order of magnitude more accurate bond length determination than that obtained by protein crystallography;

(4) XAS is an extremely fast probe (τ < 10-14 s for Fe *K-edge) that is* suitable for multiple-scale time-resolved experiments; Combination of (1)&(4) makes XAS a unique technique for probing structure of reactive intermediates in solutions.

(5) Contrary to UV-VIS and EPR spectroscopy XAS is always detectable: There are no “spectroscopically quiet” metals;

(6) XAS is capable of probing dilute samples at the micromolar level;

(7) Since XAS measurements are usually done at 10-20K, biosamples are less susceptible to x-ray beam photoreduction compared to the XRD. Photoreduction at the active center is easy to monitor via XANES.